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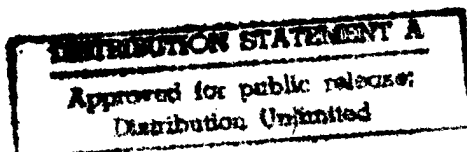
15 June 1983

# USSR Report

## MACHINE TOOLS AND METALWORKING EQUIPMENT

## No. 7

19990507 077

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# USSR REPORT

## MACHINE TOOLS AND METALWORKING EQUIPMENT

### No. 7

### CONTENTS

ERRATUM:  In JPRS 83490 of 18 May 1983, No 6 of this series,
pp 48-51 article entitled FACTORIES STRUGGLE TO OBTAIN
INDUSTRIAL ROBOTS should have been listed under
ROBOTICS category instead of OTHER METALWORKING
EQUIPMENT.

INDUSTRY PLANNING AND ECONOMICS

MACHINEBUILDING PROGRESS IN UZBEKISTAN DISCUSSED

Tashkent EKONOMIKA I ZHIZN' in Russian No 11, Nov 82 p 42

[Article by Yu. Volkov, lecturer at the Tashkent Higher Party School:
"Decisive Factor in Technological Progress"]

[Text]  The "Basic Directions for Economic and Social Development of the
USSR for 1981-1985 and for the period to 1990" states that it is necessary
"To provide for advancing development of machine building...To provide
mastery of series production of new designs for machinery, equipment, means
for automation and devices which permit highly productive energy and material
conserving technologies to be used on broad scales within short periods of
time...To increase the technical level and the quality of machine building
production."

Machine building was also mentioned in particular in the speech of comrade
Sh. R. Rashidov at the 7th Plenum of the Uzbekistan Communist Party Central
Committee.  And this is not coincidental, for this is a key branch which
determines technical progress in the national economy, a branch to which
particular attention has always been paid.

Here in the republic machine building has achieved certain successes during
the years of the Tenth Five-Year Plan.  More than 40,000 new scientific
and technical developments have been incorporated, and more than 180 auto-
matic and semiautomatic lines have been placed in operation.  The work which
has been done on technical updating of production permitted about 35,000
persons to be released and sent to other sectors and gave an economic effect
of more than R 450 million.

The Tashkent Agregate Plant is doing great work towards comprehensive
automation and mechanization of industrial processes.  Here in recent years
the relative importance of workers engaged in manual labor has been
reduced to 15 percent, and in basic production, it is to 10 percent.  Only
3 percent of the workers are employed in heavy physical labor.  The level
of mechanization and automation of production processes has reached 82
percent.  Up to 5 percent of the total number of workers is released
annually.

It is planned to incorporate 14 mechanized flow lines for machining and 2 assembly lines, to replace 114 units of obsolete equipment and to install 48 units of special and standard machine tools, automated and semiautomated units at the enterprise during the current five-year plan.

The Kalinin Brick Plant is an example of the kind of results which may be obtained even at a relatively small industrial enterprise if a course for industrial re-tooling is held consistently. This is the only one of 87 enterprises in the "Uzkolkhozstroy" system constantly overfulfilling plan quotas. As early as 1979, the plant yielded 1.5 million bricks annually. And with the incorporation of a number of technical innovations, its collective was able to increase production sharply, having produced 4 million in 1980 and 5.4 million bricks in 1981. The plan for this year is 10 million, and with the incorporation of a new trench kiln, the plant will manufacture 25 million bricks annually. Moreover, construction of this type of kiln will be less costly by a factor of 2.5 and it will require half as many workers to service it since almost all of the production processes are mechanized.

Much is being done at the republic's enterprises for incorporation of progressive industrial processes, the use of cheaper and stronger materials and the mastery of new types of items. The Novoiyskiy Mining and Metallurgical combine and the Tashkent Tractor Plant and "Tashsel'mash" Plant and certain others have accumulated valuable experience in this regard.

"The creation and incorporation of miniature electronic control machines and industrial robots will open truly revolutionary possibilities," it was noted at the 26th CPSU Congress. This is an important reserve for increasing labor productivity and the means for replacing manual labor on conveyors, at machine dies, at warehouses and in set-up shops.

The creation of industrial robots is a new branch of machine building. In our country more than 5,000 robots are already "laboring." These "smart" automated units service the die presses, reheating furnaces and casting and forging machines, they weld metal structures, they paint items and they stand along assembly conveyors. Our industry has incorporated more than 100 robot models. Their comprehensive incorporation increases labor productivity by a factor of 2-3 and each robot yields an economic effect of R8,000-12,000 per year. By the end of the five-year plan, tens of thousands of this type of automated equipment will occupy work places at enterprises. Twenty-two ministries are participating in their creation and manufacture, and the anticipated effect from their incorporation will be tens of millions of rubles.

The specialists of Tashkent Tractor Plant were one of the first in the country to set out to incorporate industrial robots into production. At the beginning of this year, an office was set up here which worked out a program of industrial process automation, calling for the creation of more than 100 robotized complexes by the end of the five-year plan. A part of them has already been given over to experimental-industrial use.

One complex of 3 robots services 5 machine tools--a centering unit with 4 lathes with numerical program control. Next to the lathe unit, 2 robotized die complexes are in operation. The effect is not just economic: people have been freed from monotonous, uninteresting work, and working conditions in the shop were improved.

Unfortunately, similar examples are isolated, and the situation is far from outstanding throughout the republic as a whole. In actuality, only 56 percent of the increase in industrial production in 1981 came as a result of increased labor productivity. The production facilities at enterprises producing mineral fertilizers are working only at 3/4 capacity, and it is even less than that for production of cement and cotton cloth. In the first quarter of 1982, the plan for labor productivity growth had not been fulfilled by 105 industrial enterprises.

The main cause is the great relative importance of manual labor, the low level of industrial discipline and inadequate use of the scientific and technical potential of machine building. It is precisely for this reason that before the end of the Eleventh Five-Year Plan it remains to provide for the growth of individual capacities of machinery and units, to accomplish the conversion from the creation and incorporation of individual machines to the development and application of finished machine systems encompassing the whole industrial process, to mechanize and automate labor intensive forms of production, first of all in the sectors where a significant number of workers are engaged in heavy manual labor, as well as at jobs under production conditions which are hazardous to the health.

Machine building is the basis for a radical rebuilding of industrial processes with the aim of developing technologies with few operations (e.g. metallurgy without a blast furnace, spinning without a spindle, or weaving without a shuttle), technologies which conserve the initial raw materials, fuel and materials to the maximum extent and which preserve the environment. The equipment which is developed should provide not only a reduction in the total number of workers, but it should also create the prerequisites for the so-called "labor-free" technology. We are speaking about the creation of such machinery, such installations which, increasing production capabilities, would not require an increase in the number of workers.

The incorporation of the achievements of science and technology, of progressive industrial processes into production is also an important factor in conservation of material and labor resources. It was on this account that the production costs of the industrial production was reduced by R16 billion during the Tenth Five-Year Plan.

Thus, the new nuclear electric power plants with 1 million kwt power units are permitting the relative capital investments and metal consumption for their construction to be reduced by 15 percent, and labor costs by 30 percent. The technical-economic indicators for nuclear power plants with channel-type power blocks rated at 1.5 million kwt are even better.

3

Rotary excavators rated at 2,500 and 5,000 tons per hour have been created and are already in use for the Siberian coal reserves. As compared with the single bucket excavators, their use will provide for a growth in labor productivity by a factor of 1.5-2, and a 20 percent reduction in operating costs and a 30-40 percent reduction in relative metal consumption.

Realization of the Food Program also depends in many ways on the successes of machine building. There are now about 2,000 kilkhozes, sovkhozes and related farm organizations, hundreds of processing enterprises and about 100 scientific research and educational institutes and experimental stations and enterprises of agricultural and irrigation machine building in the republic's agroindustrial complex.

As we see, the potential is great, but in many sectors the scientific and technical level of operations is still low. For example, many types of agricultural equipment produced by the Tashkent Tractor Plant of "Soyuzmash-khlopkovodstvo" association do not meet modern requirements. And tomorrow these requirements will be even greater--such is the regularity of scientific and technical progress.

9194
CSO: 1823/70

PRODUCTION CAPABILITY OF MACHINEBUILDING ENTERPRISES CALCULATED

[Article by Ya. Poburko, candidate of economic sciences (L'vov): "Improving Calculations of Production Capacity of a Machinebuilding Enterprise using ASUP [Automatic Control System of Enterprise]"]

[Text] At present, in many enterprises data processing, when solving technical-economic and operational calendar-planning problems, is successfully automated by using computers and economic-mathematical models. At the same time, a number of management problems in enterprises have not been solved efficiently enough in the ASUP. They also include calculations of the production capacity of an enterprise.

It should be noted that at present individual attempts to automate calculations of the production capacity have been known. They may be classified along two directions. At the basis of the first direction is the economical-mathematical model of linear programing of production capacity in the following general formulation: maximize output when limitations exist on the effective operating time fund of the equipment*. However, in practice this method was not used as widely as it merited in spite of the availability of linear programing models on computers. The latter, in our opinion, is due to the fact that the authors of these methodological instructions consider the calculation of production capacity entirely separately from solving problems of intraplant control. They assume that the initial data for building mathematical models on calculating production capacity is especially prepared. Since its preparation requires greater labor expenditures than labor expenditures on making calculations by the traditional method, the use of computer is unjustified.

Secondly, the volume of data on the production capacity of an enterprise, required by management, is outside the framework of the question about the maximum possible output. Along with this data information is also required on placing the equipment according to the technological process, its qualitative characteristics and on measures to eliminate bottlenecks etc. In other words there should be a certain system and completeness in the data on the production capacity of the enterprise.

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*Methodological instructions for calculating production capacity of electric machinebuilding plants using mathematical methods and computers. Leningrad. Izd-vo LGU [L'vov State University imeni Ivan Franko], 1974.

The second direction of automating calculations of enterprise production capacities is distinguished by the fact that a computer is used to implement instructions in effect. This direction is also not being used widely since the development of software needed for the computer involves a very great amount of work. The situation is such that existing instructions for calcuting production capacity are differentiated depending upon the type of production (machining, casting, assembling, thermal etc.) and the form of the production-technological organization of the equipment (flow-lines, automatic lines, series sections etc.). Interindustrial instructions* specify filling out about 80 forms including 6 summary and 7 general-plant forms. The number and content of the forms in the interindustrial instructions are refined depending upon the specific nature of the industry. Thus, the instructions for the motor vehicle industry** specify the filling out of more than 60 forms to calculate the production capacity of subdivisions of the shop level and lower, and more than 10 summary forms for an enterpise. To fill out these forms various initial values are used for man-hours (machine tool-hours) per unit product. For a machining enterprise this is "Norm of time per 100 units," for flow-line assemblies this is "Norm of time for an operation in norm hours," for an assembly belt it is "Conveyor cycle in units per hour," for painting-drying devices it is "Drying time in minutes," etc. Hence it is necessary, first, to develop and introduce a corresponding number of data files and, secondly, to use various algorithms to calculate the production capacity depending upon the initial data which make the use of a computer disadvantageous.

The L'vov branch of the Economics Institute of the UkSSR Academy of Sciences developed a method for calculating the production capacity of enterprises on computers, approved for the L'vov Motor Vehicle and Bus Plant, that makes it possible to reduce the man-hours for developing software and solve the problem as an optimized one and, at the same time, provide the required volume of data.

The method is based on using the principles of the general system approach to the process of control automation at the enterprise. According to the principle of a single data input into the ASUP and its multiple utilization, the calculation of the production capacity of the enterprise (production association) using computers is implemented on the basis of a single ASU [Automatic Control System] data base by the enterprise (association) with the maximum data utilization, intended for the solution of technical-economic and calendar planning, accounting, statistical reports etc. Therefore, the data base on the resources of the enterprise which determine its production capacity (Handbook "Assigning capacity resources to the technological process")contains data not only on the technological equipment and production areas of assembly subdivisions, as required by instructions, but also data on nonmechanized metalworking positions, on materials handling equipment and transport operations.

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*Interinduatrial instruction on determining production capacity of machinebuilding and metalworking plants. Parts I, II, III. Moscow NIIMASH [Scientifiv Research Institute of Machinebuilidng and Metalworking], 1979
**Guiding instruction on calculating production capacities of plant and associations in the motor vehicle industry, Parts I, II. NII avtoprom [Scientific Research Institute of the Motor Vehicle Industry]

Here, equipment, according to which the production capacity is determined, is separated by a special tag "degree of importance in the technological process."

For brevity and to develop a single calculating algorithm, the equipment and unmechanized work positions are combined into the concept "capacity resources of the enterprise." Analysis has shown that production areas in assembly shops can also be represented as a sum of nonmechanized work positions. Therefore, the formal data base on capacity resources in an enterprise are work positions according to acting technological processes. In this case, if equipment is installed at some work position, its transit capacity is determined by the transit capacity of the equipment. Otherwise it is determined by the possibilities of the workers at this work position.

The regular introduction of changes and additions to the handbook on capacity resources makes it possible to have a single file for multiple and multipurpose utilization, including for solving problems on calculating production capacity, planning and keeping records of wages.

To reduce the cost of programing, as well as to simplify the procedure for introducing data into the ASUP on operation-by-operation man-hours required for making parts, assembly units and articles, it is proposed to use a single matrix (an operation-by-operation time norm for part, unit, article) in all cases, for all types of production facilities and forms of organization of the production technological process. This data is organized into a special handbook file, in which changes and additions to the time norms are introduced constantly. The file is used to solve the problems on calculating the production capacity, but also problems of technical-economic planning, accounting records, as well as planning and keeping wage records.

To calculate the production capacity of an enterprise, in addition to the norm reference data, operational data is also utilized. This, primarily, is data on the production output plan, equipment installed or removed during the year etc. The method for organizing data on measures to eliminate bottlenecks and to raise the transit capability of capacity resources should be especially stressed. The existing instructions specify formulations entirely unacceptable for computer processing such as, for example, measures as "modernize section," build new shop" without instructions on how many machine tools will be introduced, what their operating time will be etc.

Analysis has shown that all measures on improving the structure and organization of capacity resources, on raising the level of proportionality in their synthesis, as well as those related to expanding the plant, its modernization and reequipment, are eventually reduced to the following:

change operating mode (introduce a third shift) of a group of capacity resources;

introduce a machine tool (work position) into a group of capacity resources;

remove a machine tool (work position) from a group of capacity resources;

add some volume of work temporarily to the given group of capacity resources;

remove some volume of work temporarily from the given group of capacity resources.

We will note that measures to eliminate bottlenecks are developed by technologists on the basis of preliminary calculations of the transit capability of the resources of the capacity obtained on the computer. Then this data is introduced into the computer and the production capacity of a subdivision is calculated.

The second important aspect of the method for calculating production capacity by using a computer is the reduction of the number of output forms, containing the calculation results. According to existing instructions, each subdivision, depending upon the type of production (metalworking, casting, assembling etc.) and the form of organization of the technological process (series section, flow-line etc.), designs its own group of forms whose data provides a concept of their production capacity and takes into account, in the opinion of the instruction writers, the specific natures of the organization of production in each subdivision. Moreover, the basic resulting data, contained in these forms, are essentially alike.

Analysis of data specified by the instructions on calculating the production capacity indicates that the number of forms, containing the calculation results and the initial data, may be reduced, first, by standardizing the forms of the output and the initial data and, secondly, by a clear-cut separation between the resultant reference and the operational input data. We are speaking here not about reducing the amount of data processed in making the calculations, but about reducing the number of forms and files used to calculate the forms on a computer.

The output data, i.e., the data obtained by calculations is data on the quantitative and qualitative composition of the capacity resources, the size of the production program; the man-hours and number of machine tools required; the transit capacity of each group of capacity resources, lines, sections, shops; measures that must be taken to increase the transit and production capacities; reserves of actual time fund of operation of the capacity resources; the size of the possible additional output.

Strictly speaking, it is very difficult to foresee the entire complex of indicators that may be obtained from the calculation of the production capacity. Therefore, it is expedient to consider that a certain basic file be created in the memory of the computer from which it is possible to obtain all data of interest to the user.

Forms that contain mandatory data must be standardized. It is proposed to standardize the forms in two ways. First, the production capacity of subdivisions of all kinds of manufacturing are characterized by the same forms and data contained in the forms. Secondly, a set of the same forms characterizes the production capacity of subdivisions of various profiles and hierarchies -- of the primary level (lines, technological flows, departments) and secondary

levels (sections, shops, enterprises and production associations). It is most expedient to group the mandatory data and that required by guiding organs that characterize theproduction capacity of machinebuilding enterprises and their subdivision into two basic tabulations: "Transit capacity of equipment and work positions of the subdivision" and "Production capacity of the subdivision."

Moreover, additional data may be given out in the form of addenda to the basic calculations. These are forms containing data on positioning the capacity resources (equipment and nonmechanized work positions); on the progress of the technological process; on the qualitative composition of the capacity resources and their utilization; on the distribution of the production program in groups of interchangeability of its man-hour requirements; measures to eliminate bottlenecks; list of capacity resource groups whose loading coefficient is greater than normal; a list of excess and needed equipment etc.

The use of standardized forms of norm-reference data and forms for output tabulations make it possible, first, to develop a single standardized algorithm for calculating the production capacity of an enterprise and its subdivisions independently of the type of production. Secondly, this makes it possible to collect, prepare and process data and develop a single system of rules for calculating the production capacity for subdivisions of all types of manufacturing and organization forms of the production-technological process.

The data preparation and processing technology consists of a number of sequential stages:

constant supervision of initial norm-reference data (manual for assigning capacity resources to work done, time norms for manufacturing programs etc.);

preparation and recording operational data in the computer ( production plan for the enterprise etc.);

calculation of a plan for requirements of parts and assembly units for commercial output (production plan of the enterprise );

distribution of production program between interchangeable capacity resources groups;

calculation of man-hours required for the production program by capacity resources groups;

calculation of transit capacity of interchangeable capacity resources groups;

analysis of transit capacity of capacity resources groups and identification of bottlenecks;

development of organizational-technical measures to raise the transit capacity of capacity resources groups, in particular, to eliminate bottlenecks. The work at this stage is implemented by solving such problems as the distribution and redistribution of available equipment at the plant, and the development of recommendations on the temporary redistribution of work among capacity resources groups;

adopt decisions and approve measures to increase the transit capacity of the equipment (elimination of bottlenecks), introduce corresponding data into the computer;

formation of basic data file on the transit capacity of capacity resources groups. The formation of basic output tabulations with data specified by industrial instructions for calculation of production capacity:

determination of the capacity reserves of enterprise production, taking into account the limitations on the demand for individual products.

Special features of machine data processing required concrete rules to determine the production capacity of an enterprise and its subdivisions. We can speak of three groups of rules. The first group concerns the determination of the production capacity of an enterprise, shops, sections and lines for producing concrete products. Depending upon the level of the production hierarchy, the formulas used are formulated as follows.

The production capacity of an enterprise producing concrete products is determined by the minimal transit capacity of a capacity resources group where this product is manufactured and which is in a group classified as important in determining the capacity of the plant*. In its turn, the production capacity of a shop is determined by the minimal transit capacity of a capacity resources group in which the product is processed and which, with respect to the degree of importance, belongs to groups that determine the capacity of the plant, and when there are no such resources -- to a group of capacity resources that determine the capacity of the shop. Likewise, the production capacity of a section (line) is determined by the minimal transit capacity of a capacity resources group that determines the capacity of the plant. If such resources are not available in the section -- they are then determined by a group of capacity resources that determine the production capacity of the shop. If such resources are not available -- then by the group of capacity resources that determine the production capacity of the section. The use of these rules makes it possible to use data on leading shops and leading sections (lines) within each shop. This reduces the number of input files and simplifies calculations.

The second groups of rules concerns the determination of production capacity of an enterprise (shop, section, line) for manufacturing parts, units, articles that are used for many purposes. Such purposes, as shown by analysis may be divided into four categories (with respect to importance): provide for assembly (output) of the basic product; supply other enterprises under subcontracts; provide for repair and operation needs; manufacture spare parts and consumer goods. Since these purposes are not equal, a calculation is made for each of them for the corresponding production capacity to substantiate output goals of the enterprise. The calculated rules are as follows:

*There are eight degrees of importance of capacity resources in the technical process: 1) capacity resources that determine the capacity of the plant; 2 -- of shop; 3)-- of section (line); 4)-- others; 5) used for repair services; 6) used for tool services; 7) not used in existing technology; 8) -- intended for training purposes.

The production capacity for the output of parts, units and articles of the basic product must be not less than 100% of the plan or equal to the maximum, if a plan for the basic product is not provided for;

the production capacity for the output of parts, units and articles supplied to other enterprises should be equal to 100% of the plan or the maximum, if the plan for subcontracting is not provided for;

the production capacity for the output of parts, units and articles intended for repair and operational needs should be equal to not more than 100% of the plan;

the production capacity of the output of spare parts and consumer goods should be equal to the maximum possible.

The third group of rules concerns the calculation of the production capacity of series production enterprises and shops (sections), i.e., subdivisions that manufacture several different items of the same type (intended for the same purpose), but for which demand in the national economy is varied. This problem, taking into account what was cited above, is solvable only when there is a certain reserve in the actual annual fund of time of capacity resources operation. In other words, we are speaking about the determination of the reserve in the production capacity of the enterprise and its subdivisions for the output of various items, the demand for which is different. In this case, it is best to apply a linear programing model as follows:

The loading of capacity resources of a subdivision is maximized (according to the determination of production capacity)

$$\sum_i^m \sum_j^n t_{ij}\, x_j \to \max$$

for limited reserves of actual annual fund of time of capacity resources operation

$$\sum_j^n t_{ij}\cdot x_j \leqslant \Delta t_i \quad (i = 1, 2, \ldots, n)$$

and the value of the additional demand for the product

$$0 \leqslant x_j \leqslant B_j - A_j \ (j = 1, 2, \ldots, m),$$

where $x_j$ -- the desired reserve in the production capacity for the output of the j-th item; $t_{ij}$ -- time norm for manufacturing the j-th item on the i-th group of capacity resources; $A_j$ -- directive plan for the output of the j-th item; $B_j$ -- the demand for the j-th item during the period for which the production capacity is calculated.

To solve the problem on the computer, the method envisions the automatic formation of a time $(t_{ij})$ norm on the basis of an "Operation-by-operation time norm" file, which will make it possible not only to reduce considerably the man-hours for solving the problem, but also makes possible its industrial operation.

The further development of the proposed methodology should be the development of a system for continuous calculation of the production capacity of an enterprise and its subdivisions.

2291
CSO: 1823/53

AUTOMATED CONTROL OF MACHINEBUILDING ENTERPRISES

Kiev EKONOMIKA SOVETSKOY UKRAINY in Russian No 1, Jan 83 pp 26-31

[Article by I. Petrovich, candidate of economic sciences and V. Ignatyshchenko (L'vov): "Enterprise Machine System and Control Efficiency of its Functioning"]

[Text] Improvements in the control of labor tools which function in the form of machine systems in modern enterprises acquire great importance among economic and production organization problems. The urgency of this problem increases in connection with the fact that the 26th party congress posed the problem of a sequential changeover to the mass use of highly efficient machine and technological process systems that provide for comprehensive mechanization of production and reequipment of basic industries.

Papers by Soviet economists have already covered the important methodological aspects of the problem. Thus, S. M. Yampol'skiy, developing Karl Marx's conclusions on a machine system, gave its general economic definition as the most complete form of equipment development. It is characterized by a quantitative and qualitative totality of functionally interrelated technical-economic parameters of technical labor tools acting within the framework of a closed-loop technological production method and having properties of completeness, self-organization and stability*. Planning machine systems of an industrial sector was thoroughly considered by D. M. Palterovich**.

The basic principles of organization and methodological aspects on designing a machine system for an enterprise were covered by A. P. Sidorov***. However, a number of important questions in this problem have still not been investigated. Among them, special attention must be given, in particular, to improving the organization of the control of machine systems in an existing enterprise. The machine system of an enterprise is characterized by a complex organizational synthesis. It consists of a number of corresponding subsystems that represent an equipment pool of sections, shops and plants. The subsystems have their own specific nature and fulfill certain functions within the machine system of the enterprise in the process of production. Therefore,

*EKONOMIKA SOVETSKOY UKRAINY No 7, 1980, p 5.
**VOPROSY EKONOMIKI No 3, 1976, pp 39-50.
***Sidorov, A. P. Intraplant proportions of capacities and efficiency of production. Moscow, EKONOMIKA, 1968, pp 77-101.

the reliability of the functioning of the machine system depends greatly on the efficient structure of its synthesis. The structure of the machine system means the totality of the stable organizational-technical ties between its subsystems and the individual components in each subsystem. Therefore, the system itself may be considered, on the one hand, as separated into a number of machine subsystems, operating in shops and sections and, on the other hand, as a single whole -- a production equipment pool of a section, shop, plant and association.
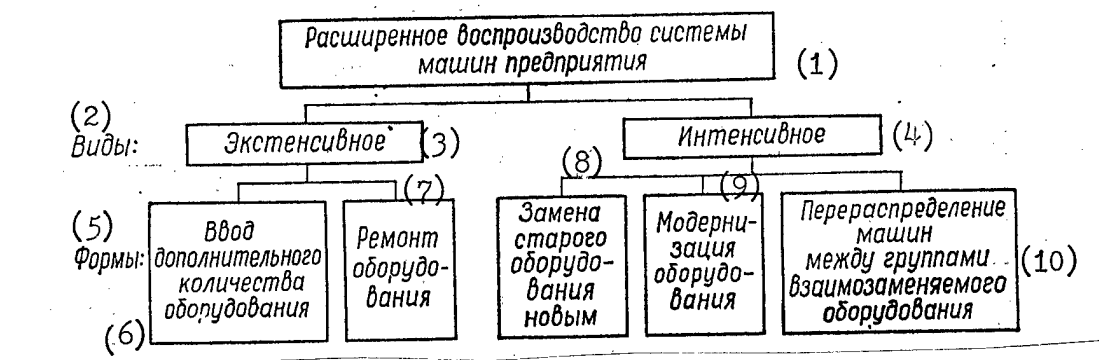
The separation of the machine system is necessary for many reasons and is objectively stipulated by the design-technological special features of the manufactured products. At the same time, separation presents a picture about the quantitative composition of various subsystems, as well as about their disposition in space and functioning in time. It is especially important that the machine system of the enterprise have a dynamic nature. A qualitative, as well as a quantitative change should occur in its composition.

If the effect of the objective factors on changing the structure of the machine system is not taken into account, this will reflect on the efficiency of its utilization. This effect is especially sensitive when there is a frequent change in products and in the technology improvement of manufacturing. In many cities, production assimilation of new or modernized products causes changes in the structure of the machine system in the plant and, sometimes, requires a radical change. New technology has an important role in this. Thus, the introduction of progressive methods for manufacturing intermediate products in machinebuilding and getting their sizes and shapes closer to those of the finished products results in a considerable change in the qualitative and quantitative composition of the machine system of machining production which, in the final result, is reflected in the rearrangement of its structure.

The necessity and importance of clear-cut coordination of all components of the machine system of the enterprise, which are in a state of constant motion and development is also stipulated by the fact that the production process in machinebuilding has a discrete nature. Hence maintaining stable ties between system components by corresponding regulating methods acquires considerable practical value since it makes it possible to maintain the system always in working condition. This is especially important because at machinebuilding enterprises, in order to increase the efficiency of controlling production processes, it is necessary to separate ties between types of individual equipment and units in lines, sections and shops, as well as between the lines, sections and shops. Therefore, the achievement of a stable structure of the machine system at a plant demands constant regulation of its components and an improvement in the organizational ties between them, i.e., control of the machine system of the plant. Only in that case is it possible to have the machine system of the enterprise function most efficiently.

The goal of controlling the machine system of an enterprise is tobe able to manufacture a quantity and variety of products according to the plan by means of a given machine system for the enterprise. Various external factors act on the machine system of the plant in the process of functioning: a change in

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the list of products and volume of production; creation of new more productive and less costly machines and sets; development of new materials and technological processes etc. Therefore, to provide the normal progress of the production process, a corresponding modernization of the machine system is required, as well as some changes in the qualitative and quantitative composition of the machine tool pool and its reproduction. By reproduction of the machine system of an industrial enterprise we will mean a systematic process of constant renewal of the composition of the components of the machine (machine tools, machines and sets) and their interrelation in the process of production. A simple reproduction of the machine system may be provided by timely machine tool repairs and by replacing worn-out equipment by new. Expanded reproduction of the machine system occurs at the majority of enterprises. In this case, there is observed quantitative (extensive reproduction), as well as qualitative (intensive reproduction) changes in the machine tool pool. In the arrangement shown below, types and forms of expanded reproduction of a machine system in an existing enterprise are shown.

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                    ┌──────────────────────────────────────┐
                    │  Расширенное воспроизводство системы   │  (1)
                    │          машин предприятия             │
                    └──────────────────────────────────────┘
  (2)                    │                         │
  Виды:   ┌─────────────────────┐          ┌─────────────────────┐
          │   Экстенсивное (3)  │          │   Интенсивное  (4)  │
          └─────────────────────┘   (8)    └─────────────────────┘
                 │        (7)                    (9)
  (5)    ┌───────────┐ ┌──────────┐ ┌──────────┐ ┌──────────┐ ┌─────────────────┐
  Формы: │   Ввод    │ │ Ремонт   │ │ Замена   │ │ Модерни- │ │ Перераспределение│
         │дополнитель-│ │оборудо-  │ │ старого  │ │  зация   │ │      машин       │ (10)
         │   ного     │ │  вания   │ │оборудо-  │ │оборудо-  │ │ между группами   │
         │количества  │ │          │ │  вания   │ │  вания   │ │ взаимозаменяемого│
         │оборудования│ │          │ │  новым   │ │          │ │   оборудования   │
         └───────────┘ └──────────┘ └──────────┘ └──────────┘ └─────────────────┘
  (6)
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1. Expanded reproduction of the machine system of an enterprise
2. Types
3. Extensive
4. Intensive
5. Forms
6. Introduction of additional quantity of equipment
7. Equipment repairs
8. Replacement of old equipment by new
9. Modernization of equipment
10. Redistribution of machines between groups of equipment being interchanged

Being as a whole of a dynamic nature, the machine system of an enterprise can, at the same time, function in a stable manner for a comparatively long period. However, deviations from stable functioning may be possible. These deviations are reflected in the transit capacity of individual machines and

subsystems at various levels of the hierarchic structure of the machine system. Some have minimal transit capacity for executing a given volume of production, while others -- maximal. Therefore, the average loading coefficient of equipment in the machine system of the enterprise is low and reflects directly on the level of the output-capital ratio.

The problem originates of improving the utilization of the machine system of the plant by increasing the average equipment loading. The increase in machine tool loading should not be limitless, but have some finite limit that is optimal. As such, a limit may be assumed for an equipment loading coefficient norm $(k_H)$ that determines the economically substantiated underloading of the machine tools. This coefficient indicates that for any group of interchangeable equipment normal should mean its utilization of the actual annual fund of time ( $\Phi_i$ ) not fully, but only time equal to $\Phi_i k_H$. Value $\Phi_i$ $(1-k_H)$ will be the norm reserve of this fund of time which will make it possible to have some reserve capacity for timely reaction to all possible external and internal effects.

An indicator that characterizes the degree of utilization of the plant machine system to its optimal value is the mean square deviation of enterprise equipment loading coefficients from their normal values:

$$\Delta k^2_{cp} = \frac{\sum_i (k_i - k_H)^2 n_i}{\sum_i n_i} =$$

$$= \frac{\sum_i \left(\frac{T_i}{f_i n_i} - k_H\right)^2 n_i}{\sum_i n_i}, \quad \text{(I)}$$

where $k_i$ -- loading coefficient of the i-th group of interchangeable equipment; $k_H$ -- equipment loading coefficient norm; $n_i$ -- number of machine tools in the i-th group of interchangeable equipment (units); $T_i$ -- machine tool capacity for work assigned to the i-th group of interchangeable equipment (machine-hours); $f_i$ -- actual annual fund of time of one machine tool in the i-th group of interchangeable equipment (hours).

We will determine for which $n_i$ the mean square deviation of loading coefficients from their norm value $\Delta k^2_{cp}$ will be minimal. We will assume that values $n_i$ may vary continuously: then they will determine the rate quantity of machine tools in the i-th group of interchangeable equipment. We will consider values $T_i$ and $f_i$ as given.

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To find the extremum of function

$$\Delta k_{cp}^2 = \varphi(n_i),$$

represented by expression I, we will determine partial derivatives

$$\varphi'(n_i)_{n_1}, \quad \varphi'(n_i)_{n_2} \quad \dots, \quad \varphi'(n_i)_{n_I}$$

and equate them to zero. It follows from the obtained system of equations that

$$\frac{T_1}{f_1 n_1} = \frac{T_2}{f_2 n_2} = \dots = \frac{T_i}{f_i \, n_i} = \dots = \frac{T_I}{f_I \; n_I} = k_{\text{H}}.$$

for

$$k_i = \frac{T_i}{f_i n_i} = k_{\text{H}}$$

the mean square deviation $\Delta k_{cp}^2$ reduces to zero.

Changing from the load coefficient to the transit capacity of the machine tools

$$(\eta_i = \frac{1}{k_i}),$$

we have

$$\eta_1 = \eta_2 = \dots = \eta_i = \eta_{\text{H}} = \frac{1}{k_{\text{H}}},$$

where $\eta_{\text{H}}$ -- norm transit capacity of the equipment.

Thus, the most efficient synthesis of the machine system of a plant is achieved when loading coefficients of all interchangeable equipment groups are equal to each other and the norm of the loading coefficient. Therefore, the equipment loading norm may be provided by observing the proportionality between the structure of the machine tool pool and the structure of the laboriousness of the work to be done, i.e., when:

$$T_1 : T_2 : \dots : T_I = \Phi_1 : \Phi_2 : \dots : \Phi_I,$$

where

$$\dot\Phi_i = f_i \, n_i —$$

is the actual annual time fund of operation of the i-th group of the inter-changeable equipment.

The machine system can function most efficiently under such circumstances. As a result, each machine and subsystem participates in the work for an equal amount of time, the production process is implemented on an expanded basis which, in the final result, is reflected in a higher output-capital ratio. Therefore, higher efficiency of the utilization of fixed production capital must be based on the stability of the machine system functioning in whose synthesis a high proportionality level was achieved. The observance of proportions in the value of the transit capacity of machine systems is an objective necessity. Karl Marx stressed that "... the fabrication of a given amount of product during a given working time becomes the technical law of the production process itself"*. The most clear-cut reflection of this law is found in machine production. "In machine production... the entire process depending on its own nature breaks up objectively into its component phases, and the problem of implementing each partial process and combination of various processes is solved by the technical use of mechanics, chemistry etc....., while, obviously, the theoretical solution may be improved, as before, by means of practical experience accumulated on a large scale"**. Thus, the "technical law of production itself" requires equality of output by individual participants in production -- the production subdivisions. The amount of this output depends, to a great degree, on the relationship between the transit capacities of the machine systems of the subdivisions. The better this relationship, the broader the scale of production and the higher the output-capital ratio.

Expanded machine system reproduction of an enterprise must provide a high proportionality of its synthesis which will produce stable functioning. Here is required proper organization in implementing the reproduction processes. At modern enterprises, managers implement elements of planning, accounting, monitoring and regulating the machine tool pool of the enterprise. Here also originates the reproduction of the machine system. However, spontaneously, without sufficient substantiation, a thorough analysis of the expediency of the changes being made and their economic results are realized. An analysis of the dynamics of the machine tool pool of a number of machinebuilding enterprises in the UkSSR western oblasts indicates that there are considerable shortcomings in the development process of plant machine systems. For example, there is a large quantity of unused equipment in active technology, as well as idle (surplus) production capacity. Moreover, frequently unsubstantiated new equipment is introduced, although the enterprise has similar equipment standing idle. Therefore, there is no stability in the functioning of the machine system.

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*Marx, K., Engels, F. Collected Works, vol 23, p 358.
** Ibid. p 391.

Table 1

Dynamics of change in quantitative composition of equipment at the L'vov
Motor Vehicle Bus Plant during 1976-1980 (units)

| Name of equipment | Years | | | | |
| --- | --- | --- | --- | --- | --- |
| | 1976 | 1977 | 1978 | 1979 | 1980 |
| Total quantity of equipment at start of year | 2355 | 2514 | 2716 | 2856 | 2991 |
| Equipment not installed (new -- intended for output of new products) | 23 | 22 | 14 | 12 | 2 |
| Equipment installed and not used because of new technology introduced | 631 | 411 | 445 | 187 | 143 |
| Equipment not loaded according to estimated production capacity (surplus according to estimated production capacity | 67 | 65 | 31 | 29 | 25 |
| Equipment put into operation during the year | 149 | 135 | 120 | 61 | 80 |
| Equipment removed during the year | 29 | 37 | 16 | 14 | 10 |

At the modern stage of production control, many necessary calculations on
planning and regulating the pool of technological equipment in the enterprises
are practically not made. For example, in 1976 at the L'vov Motor Vehicle
and Bus Plant unused and surplus equipment was 29.6% of the total. By the
start of 1980 this decreased to 4.8%, but is still high -- 143 machine tools.
As shown in Table 1, along with the reduction in surplus equipment, the
number of newly introduced machine tools also decreased. However, an analy-
sis indicated that a considerable portion of the new equipment is not needed
by the enterprise because they already have such machine tools not used in
present technology or are surplus (see Table 2). Therefore, the machine sys-
tem is not being controlled entirely efficiently at present. All this is
the result of unsatisfactory organization of production. One reason for this
is management's lack of operational, authentic and complete data on the

equipment available at the enterprise, its condition, movement and utilization. Moreover, due to the laboriousness of calculations it is impossible to solve the following optimization problems manually: development of recommendations for raising the transit capacity of the equipment at bottlenecks, development of recommendations on eliminating disproportions in the machine system of the enterprise, preparation of optimal equipment repair schedules and the determination of production capacity of the enterprise and others.

Table 2

Possibility of satisfying equipment requirements by inner reserves at L'vov enterprises in 1979

| Enterprises | Equipment introduced(% of total) | Idle equipment of same models as the one being introduced (% of that introduced) |
|---|---|---|
| Motor Vehicle Bus Plant | 2.1 | 37.7 |
| Lift Truck Plant | 0.1 | 50.0 |
| Motor Vehicle Plant | 2.6 | 17.2 |
| "L'vovsel'mash" | 3.5 | 28.6 |
| Milling Machine Plant | 2.6 | 43.8 |

As is well known, great possibilities open up to gather, process, store and accumulate necessary data by using computers in an automatic control system of an enterprise (ASUP). Existing ASU [Automatic Control System] cannot provide exhaustive all-sided data on the production capacities of an enterprise -- the base for controlling the machine tool pool, not even to speak of data for controlling the machine system itself. For example, general industrial methodological materials on creating ASU for enterprises and associations* recommend,for introduction,a very scant list of problems concerning the considered problem. In a basic production control subsystem it is planned to calculate loadings and transit capacities of equipment (by shops, sections, per year and per quarter) and make an accounting of idle time of equipment (by shop for days since the beginning of the month). In the auxiliary production control subsystem it is planned to calculate the planned preventive maintenance repairs (PPR) schedule and the volume of repair works (for enterprise, shop per year, quarter, month). In the technical-economic control subsystem forming a production program for a maximum equipment loading (for the enterprise per year) is recommended. In the long-range list of ASPU problems,

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*General industrial methodological materials for creating ASPU. Moscow, "Statistika," 1977.

among questions of interest to us, are only a number of problems in the auxiliary production control subsystem, namely: estimates of optimal schedules for replacing wornout equipment (for enterprise, shop per year); estimate of labor, material and money expenditures for maintaining and operating equipment (in shop, enterprise per year, month); a statistical analysis of accounting data on malfunctions in and and costs of maintaining and operating equipment (for shop, enterprise per year).

An analysis of acting ASUP operation indicates that, basically, in each one of them, some problem or problems on controlling the machine system are solved, but in any system taken separately, the problems are considered usually one-sidedly and incompletely. Problems concerning control of enterprise machine systems, solved within the framework of existing ASUP, may be grouped as follows: calculation of production capacity of an enterprise and its subdivisions at the start of the year, at the end of the year and at the middle of the year; calculation of the optimal production program taking into account equipment loading; calculation of the equipment composition, movements and requirements; calculation of the utilization of the production equipment, the annual PPR schedule and the volume of repair work.

However, even if all these problems were solved at one enterprise, this would not provide the necessary data for the successful control of its machine system. Therefore, it is necessary to synthesize, in the ASPU framework, a complete subsystem which would span thoroughly all forms of enterprise machine system reproduction. It must contain, first, a complex of problems to calculate the transit capacity and loading of technological equipment, and the determination of the production capacity of the enterprise. These calculations will provide data for the following implementation of regulating the qualitative and quantitative composition of the machine system to achieve stable functioning. Thus, when data is available on equipment loading it will be possible to detect bottlenecks and excess capacity and determine proportions or disproportions in the machine system structure. Such calculations will make it possible to produce, by means of computers, economically substantiated recommendations to eliminate or reduce outdated and wornout equipment, improve the available machine tool pool and expand or curtail production.

In our opinion, an enterprise machine system control subsystem should include two complexes of problems. The first complex will contain problems on calculating production capacities of enterprises that include: the quantitative and qualitative characteristics of the machine system of the production subdivision; calculation of laboriousness (machine tool capacity) of work assigned to a group of interchangeable equipment; calculation of the transit capacity of groups of interchangeable equipment; determination of production capacity of plant production subdivisions; determination of plant production capacity for commercial product output; determination of additional product output by available production capacities; and the determination of the optimal production program of the enterprise.

The second complex consists of problems on direct enterprise machine system control. Among them it is necessary to mention the following: calculation of new equipment requirements for the five-year plan and for a particular year;

determination of optimal service life of the equipment; calculation of the optimal schedules for planned preventive maintenance of equipment repairs; calculation of the economic efficiency of modernization and equipment replacement; accounting for and monitoring equipment shifts; accounting of planned preventive maintenance repairs and modernizing equipment; accounting for and monitoring replacement and removal of equipment; development of recommendations on the distribution and redistribution of available equipment; smoothing the disproportions in production capacities of enterprises (optimal elimination of bottlenecks);identifying surplus equipment and several others.

Thus, creation of the machine system control subsystem within the ASUP framework will provide the enterprise management with complete, authentic and rapid data on the condition of the machine tool pool and its utilization at any given moment. On the other hand, availability of data of a given subsystem will make it possible to develop recommendations for assuming correct substantiated decisions which reflect the economic consequences of their implementation. This will raise to a qualitatively new level the processes of development of the administrative production organization; raise the dynamism and flexibility of the machine system; make it possible for industrial enterprises to adapt themselves more rapidly at lower costs to changes in the volumes of production and the list of products; and insure efficient reproduction of the plant machine system and the stability of its functioning.

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CSO: 1823/53

PROBLEMS IMPEDING SUPERPOWERED MACHINERY PRODUCTION DISCUSSED

Kiev RABOCHAYA GAZETA in Russian 2 Feb 83 p 2

[Article by B. Medovar, academician of UkSSR Academy of Sciences, deputy to UkSSR Supreme Soviet, chief of department at Institute of Electrowelding imeni Ye.O. Paton, Kiev: "It Is Time to Break Down Barriers--What Is Hindering the Building of Superpowered Power Machinery?"]

[Text] In accordance with the decisions of the 26th CPSU Congress, a broad program is being carried out of construction of nuclear electric power stations. In our republic alone, there are being erected 7 nuclear powered electric giants with a total capacity of more than 20 million kilowatts.

A characteristic feature of modern AES is the higher unit capacity of the power units--from 1 million kilowatts and more. They improve efficiency in the use of fuel and reduce specific construction costs. In a word, they are effective from all points of view.

In order to build such power units, it is necessary to develop the production of tremendous turbines and generators. From a scientific and engineering point of view, this superdifficult problem has been successfully solved. But recently, unexpected obstacles have sprung up in the way of building such machinery.

Here, however, it is necessary to return to history, albeit not too remote. A general outline of a program of intensive development of atomic energy was drawn back in the sixties. It was then that scientists, planners and design organizations and ministries and departments were assigned the task of preparing a domestic industry for the building of a large number of superpowered nuclear electric power stations. A colossal amount of work was carried out. Not only new designs of machines and mechanisms were created. A scientific experimental evaluation was carried out of technologies and capacities current in industry capable of handling orders for the production of equipment for AES and plans were made for new enterprises, shops and units. This is how the famous Atommash [exact rendering unknown, but on the order of Nuclear-Powered Machine Administration]. At the Sumy Production Association imeni Frunze, unique shops were erected for the production of no less unique superreliable

circulation pumps for the main circumference of the nuclear reactor.  New
materials, new kinds of metals and so on were created.

Our institute was drawn into the solution of technical of problems of creating
shafts for the rotors of gigantic turbines and generators, whose length is
as much as 14 meters and the diameter--2 meters.  The weight of such a detail
in its pure form is about 200-250 tons, while the blanks weigh as much as
500 tons.

What sort of difficulty did this involve?  In order to get a blank for such
a gigantic part, it was necessary as a minimum to have an ingot of a size
that had as yet not been produced in our country.  It would have been possible
to approach it in the traditional way.  To calculate, to test the conditions
of crystallization of a large quantity of melted steel, to make a tremendous
mold with a holding capacity of up to 500 tons and finally to produce the re-
quired ingot.  But here difficulties arose not only of a technical but also
of an organizational character.

According to the technological scheme of machine-building production in our
country, each of the large plants of this sector possesses its own steel-
casting capacities.  Moreover, they are naturally used intensively and are
simply unable to accept orders for the production of ingots for a large number
of rotors for power machines.

Consequently, in order to make such blanks according to the customary method,
it was necesszary to bring in additional capacities capable of producing
500 tons of steel in one melt.  The customary way of producing multi-ton
ingots has given rise to other new long-realized and expensive problems.

Then our institute proposed to produce ingots on the basis of electric-slag
technology.

What is the nature of the idea?  Electric-slag  ingots, as we know, are
produced not in molds but in crystallizing tanks in the process of electric-
slag remelting.  It was proposed to obtain from steel electrodes weighing up
to 30 tons ingots with a mass of 150-200 tons and then to weld them into
blanks of double or triple mass.  The gain was undoubted.  In addition,
the quality of the metal produced by means of electric-slag remelting was
undoubtedly higher than usual.  Furthermore, the structure of the ingots was
superior.  And this is extremely important.  The fact is that the rotor
of a generator with a 1-million watt capacity, for example, operates, as
they say, under extreme conditions.  It rotates with all its tremendous mass
at a rate of 1,500 revolutions  per minute  and must withstand arising over-
loads for decades.

The promising aspect of the proposed technology stems from the fact that
it where necessary makes it possible to increase the mass to practically an
unlimited extent of the monolithic welded blank.

The idea was approved at all pertinent levels, and the institute undertook to
realize it.  First of all, there was developed  and designed a unique device

for electric-slag welding of ingots with a 2.5-meter cross section. The unit successfully passed tests at the Izhorskiy Plant imeni Zhdanov. With its help, experimental welded blanks were made for rotors with a 125-ton mass from, true, ordinary ingots cast in 60-ton molds. The scrupulous examination of the weld showed its high quality. A shaft was produced at the Izhorskiy plant with the aid of our device which has gone into a generator with a 1,000-megawatt capacity for the Kalinin AES.

But the requirements of the broad program of building nuclear electric power stations planned for the '80s are not covered by the Izhorskiy installation; it was created in fact as something experimental and industrial.

And then in the seventies, construction of a complex was started that would be fully capable of handling the requirements of the power engineers. It came to include an electric-slag furnace for the remelting of these electrodes into ingots with an up to 200-ton mass and a welding installation of the VIII-122 type for their welding into blanks of rotor shafts for turbines and generators.

These units were located at the Novokramatorsk Machine-Building Plant imeni V.I. Lenin. For the manufacture of the used electrodes, an installation for semicontinuous casting of forging ingots was erected at a neighboring casting and forging plant; it for all practical purposes was part of the complex being built.

Such an arrangement was no accident. Both of these enterprises belonged to the same ministry--the USSR Ministry of Heavy and Transport Machine Building. The productivity of the semicontinuous casting installation was higher than the capability of the 200-ton electric-slag furnace, and the excess blanks had to be worked at the casting and forging plant. The Novokramatorsk workers, in addition to blanks for power-machine shafts, were enabled to have blanks as well for shafts of superpowered rolling mills--the basic product of the Novokramatorsk plant.

Nonetheless not a single blank has come out of the finished complex! Moreover, their production is just not being planned. But the requirements of the power engineers--after all the nuclear electric power stations continue to be built-- the Ministry of Power Machine Building proposes to satisfy through the purchase abroad of blanks for the shafts!

I shall not conceal the fact: we scientists, the creators of this unique technology, were, to put it mildly, surprised by such a position of the Ministry of Power Machine Building. I shall not speak of the feelings of work dissatisfaction. Even from an economic point of view, an illogical situation was created. Instead of shipping abroad blanks of shafts--the capacity of the erected complex makes this fully possible--the country is obliged to import expensive ingots!

What happened? The developed situation can be simply explained.

In 1975, the Ministry of Heavy, Power and Transport Machine Building was broken up into two agencies: the Ministry of Heavy and Transport Machine Building

and the Ministry of Power Machine Building. The Novokramatorsk Machine-Building Plant remained under the aegis of the first ministry, while the casting and forging plant was turned over to the newly created agency and has now come to be called the Energomashspetsstal' Plant.

It would have been all right if only the name had been changed. The relations between the two enterprises underwent a sharp change, although they were located practically on the same grounds 100 meters from each other. The Energomashspetsstal' Plant, after testing the installation for semicontinuous casting of forging ingots, refused to supply them to the Novokramatorsk plant. Perhaps the unit was overloaded? By no means. It, if one can believe this, but it is a fact, has not been used since 1981.

Regardless of the times the Novokramatorsk people requested the Ministry of Power Machine Building to oblige Energomashspetsstal' Plant to provide them with the electrode ingots, they were unable to obtain a positive answer.

Thus because of its own inability to organize or its lack of desire to cooperate with the Novokramatorsk plant, the Ministry of Power Machine Building is without blanks for the machine parts for which this ministry was actually created. But such an approach to the matter results in significant loss to the state—the price of such blanks on the international market is in the hundreds of thousands of dollars.

What can and should be done under these conditions?

First of all, break down the interdepartmental barrier. Have the Ministry of Heavy and Transport Machine Building and the Ministry of Power Machine Building sit down at a table for talks with the desire to help each other in organization of the work. Determine and outline a clear-cut program of fabrication of welded-forged blanks for rotor shafts of generators for 1985 and the subsequent period. Work out measures for elimination of bottlenecks, which hinder the realization of progressive technology.


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UDC 621.9.06.002.2:658.511.3](479.25)

LABOR-CONSUMING QUALITY OF MACHINING ANALYZED

Yerevan PROMYSHLENNOST' ARMENII in Russian No 12, Dec 82 pp 46-47

[Article by V. G. Abramyan, Economist:  "Analysis of the Labor-Consuming Quality of Machining in Production of Machine Tools"]

[Text]  The creation of fundamentally new, efficient machining methods and improvement of equipment designs are the principle directions for further development of machine tool building.  This will permit the degree of process discreteness to be reduced substantially and it will provide an increase in the extent of process continuity and concentration.

According to calculations by specialists, the entirety of factors determining the productivity of working machinery directly due to using new technology and improving equipment designs will make it possible to provide an approximate 35-40 percent growth in labor productivity.  The remaining 60-65 percent should be achieved by increasing the level of machinery automation and comprehensive automation of production.
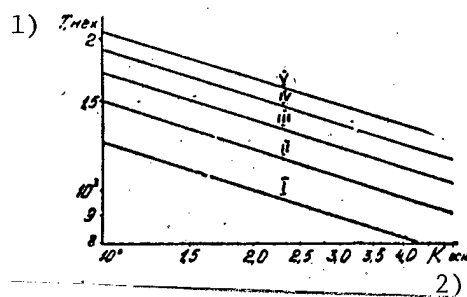


Machine tool mass (kg):
I - 10,000; II - 15,000;
III - 20,000; IV - 25,000;
V - 30,000.

KEY:  1) $T_{mech.}$
      2) $K_{basic}$

In connection with this, an increase in production of automatic machinery and semi-automatic machinery, equipment with numerical program control, machine tools with increased precision, etc, are being contemplated for first of all in the plans for the new five-year plan and for the period to 1990.

At the machine tool building plants in Armenia, analogous changes in the standardization of machine tools being produced are also taking place.

When creating new machine tools, it is necessary to strive for reduction of the periods for project planning and for incorporating them into production. The precise determination of the values of industrial labor-intensity of machine tool production at the stage of preparation for production is also important.

The labor-intensiveness of machining, the relative importance of which is 30-40 percent, occupies a particular place in the industrial labor-intensiveness of the production of machine tools. Determining the magnitude of machining and knowing its structure, it is possible to determine the necessary production capacity for organization of production at the project design stage.

In the scientific literature, labor-intensiveness of machining is determined by the following 3 methods: by the specific labor-intensiveness of a unit of mass; by using a consolidated method based on similarity and with the aid of correlation models.

The first method is adequately simple and applicable for approximate calculations.

The limitation of the second method is associated with the fact that one cannot succeed in selecting an analogous part within the primary parts list for every part in the project design stage.

An analysis of statistical data for 23 groups of machine tools (more than 160 models) showed that the most progressive method is the third.

Based on the analysis of an order of 30 factors it was revealed that mainly 3 factors influence the machining labor-intensiveness for production of machine tools: the mass of the initial part blanks which are machined at a plant ($m$, kg); the coefficient for the extent of industrial equipment ($K_{basic}$) and the number of years an item has been in production ($t$).

The mass of the initial part planks which are machined at the plant may be determined at the stage for preparation for production based on the net mass of these parts and the average coefficient of metal usage.

The coefficient for the extent of industrial equipment is determined as the ratio of the amount of equipment to the number of names for original machine tool parts which have been machined at a plant.

As is known, labor-intensiveness for manufacture of an item after it has been incorporated decreases each year. This fact attests to the fact that the number of years that an item has been in production must be taken into consideration as a primary factor. The annual decline in labor-intensiveness may also be determined with its assistance if other design-technological and organizational measures are not realized.

The calculated labor-intensiveness ($T_{cal}$) for each of the 23 groups of machine tools is determined according to the following formula (cf. figure):

$$T_{cal} + A \cdot M^x \cdot K^y_{basic} \cdot e^{tz},$$

where $\underline{A}$, $\underline{x}$, $\underline{y}$, $\underline{z}$ are a constant value and exponents and $\underline{e}$ is the natural logarithm base.

For labor-intensiveness of machining, the average mean deviation of empirical values from the theoretical values does not exceed 5 percent by groups.

The multiple correlation coefficients are no lower than 0.9 by groups, and the determination coefficients are 0.8, i.e., the factors are properly chosen.

To increase the accuracy of the correlation equations, it is necessary to correct them:

$$T_{cal}^{cor} = T_{cal} \cdot K_{cor}.$$

| 1) Факторы | 2) Горизонтально-расточные станки | | | | | |
|---|---|---|---|---|---|---|
| | 2М614 3) | 2620Б 4) | 2620ВФ 5) | 2622В 6) | 2636 | 263ГФ 7) |
| 8) м | 11848 | 17016 | 17016 | 16505 | 53105 | 47790 |
| 9) $K_{осн}$ | 2,877 | 1,573 | 1,696 | 1,652 | 1,130 | 1,109 |
| 10) t | 7 | 15 | 13 | 16 | 11 | 8 |
| 11) Т | 1232,2 | 937 | 1082 | 822,8 | 2427 | 2912,4 |
| 12) $T_p$ | 1230,4 | 900 | 1038,5 | 813,8 | 2505,7 | 2972,1 |
| 13) $K_{пт}$ | 2,139 | 2,050 | 2,051 | 2,095 | 2,174 | 2,150 |
| 14) $T_p^{кор}$ | 1211,3 | 347,4 | 10924 | 827,8 | 2404,8 | 2902,4 |

KEY: 1)  factors
     2)  borers
     3)  2M614
     4)  2620B
     5)  2620VF
     6)  2622V
     7)  2636GF
     8)  m
     9)  $K_{basic}$--Coefficient for extent of industrial equipment
     10) t

11)  T

12)  $T_{cal}$ -- Calculated labor-intensiveness

13)  $K_{ase}$ -- Coefficient of advanced state of equipment

14)  $T_{cal}^{cor}$ -- Calculated labor-intensiveness, corrected

The correction coefficients ($K_{basic}$) are determined for each subgroup of machine tools as a function of the value of the coefficient for the advanced state of the equipment ($K_{ase}$) ["progressivnost' tekhnologii"], which is determined for each machine tool model.

For example, for borers (cf. table):

$$T_{cal} = 10 \cdot {}_M 0.59 \cdot K_{basic}^{-0.15} e^{-0.08t};$$

$$K_{cor} = 3.26 \cdot K_{ase}^{-1.58}.$$

Determining such dependencies for each group of machine tools, it is possible to determine the labor-intensiveness for machining new machine tools at the stage of preparing for production with great accuracy, and one may predict the magnitude of labor-intensiveness for machining and plan for its yearly reduction as well.

The relationships and characteristics obtained make it possible to determine available reserves for reducing the labor-intensiveness of production that has a decisive significance for the growth of labor productivity.

9194
CSO:  1823/44

AUTOMATED LINES & AGGREGATE MACHINING SYSTEMS

COMPUTER NUMERICAL SYSTEMS PLANNED

[Article by candidate of technical sciences V. A. Kruglov: "Automated Technological Complexes Controlled From a Computer]

[Text]  Automation of production machining under conditions of multiple-product and short-run production is urgent in view of a deficit in labor resources and the necessity of developing capacities by intensifying production when improving working conditions and raising industrial efficiency.

The creation of flexible machining systems [computer-operated] (GAK) and flexible machining production (GAP) is an effective course for solving the problems of developing capacities and the comprehensive automation of porduction machining.  Solution of the indicated problems has particular relevance in high-precision machine and instrument building where processing accuracy is one of the main criteria determining production efficiency.  When processing complex housings, printed circuit boards, foundations, frames and other components, it is necessary to ensure high accuracy of diametric dimensions and mutual configuration of processed surfaces.  Controlled parameters and their correlation are cited in the table.

The necessity of ensuring the prescribed precision and automated processing of housing components requires the introduction of high-performance and precision equipment, the creation of automated sections and workshops for processing on machine tools with computer numerical control [CNC], and an increase in the efficiency of using equipment and production areas with regard to the prognosis for developing machine and instrument building.

The introduction of milling machines with numerical control [NC] and machining centers with tools that can perform a wide variety of machining tasks in a complex with drill-layout machines with NC and manual control for the processing of a pattern of especially precise openings is one of the efficient ways for automating production and for increasing output and accuracy during the processing of small housing components (with a dimension less than 350x350x350 millimeters).  The machine tools are united into automated technological complexes (ATK) forming GAK and GAP.

| Conditions | Overall Volume of Measurements | Accuracy, millimeters | | |
|---|---|---|---|---|
| | | 0.002– 0.005 | 0.006– 0.010 | 0.01– 0.03 |
| Misalignment | 33 | 12.2 | 30.4 | 57.4 |
| Nonperpendicularity of face to rotation surface | 19.6 | 21.3 | 25.6 | 53.1 |
| Nonparallelism of axes and planes | 10.3 | 10 | 80 | 10 |
| Nonperpendicularity of axes | 7.3 | -- | 85.7 | 14.3 |
| Nonintersection of axes | 3.0 | -- | 15 | 85 |
| Nonperpendicularity of axes and planes | 4.0 | -- | -- | 100 |
| | 6.3 | 15 | 64 | 21 |
| Nonparallelism of planes | 4.0 | -- | 100 | -- |
| Nonparallelism of axes | 2.2 | -- | 44 | 56 |
| Nonperpendicularity of planes | 3.3 | -- | -- | 100 |
| Complex tolerance for misalignment of openings and nonperpendicularity of their faces | 3.5 | -- | 46 | -- |
| Accuracy of interaxial and coordinated dimensions of placed openings | 3.5 | -- | -- | 54 |

During processing on machine tools with NC and in processing centers, analysis indicates that it is possible to obtain the following accuracy of machined parts elements and their mutual configuration: second to third class according to diametric dimensions; 0.01 millimeter according to alignment of openings; 0.015 millimeter according to nonperpedicularity of axes; 0.01 millimeter according to nonintersection of axes; and fourth to fifth class according to longitudinal dimensions. It is necessary to use drill-layout machines with NC or with manual control for ensuring higher processing accuracy.

The resources of enterprises for automated processing of complex housing components with an arrangement of high-precision openings have grown in connection with the increased output of drill-layout machines with NC and coordinates-measuring machines (KIM), including those with NC.

It is necessary to introduce KIM for automating parameter control of the accuracy of arrangements with high precision openings. The KIM which were created on the basis of drill-layout machines by the Vil'nyus branch of ENIMS [Experimental Scientific Research Institute of Metal-Cutting Machine Tools] in conjunction with the Kaunas Machine Tool Plant imeni F. E. Dzerzhinskiy and the Kuybyshev Coordinates-Measuring Machine Plant have the greatest accuracy among the domestic KIM. The KIM models 2431I, 2455I and others are equipped with NC with a printer output of measurement results that makes it possible to raise the level of automated monitoring operations when manufacturing complex high-precision housing components. A significant increase in the introduction of machine tools with NC is foreseen in the enterprises of various branches of machine and instrument building: from 3.6 percent in 1980 to 9.38 percent in 1985.

For more efficient use of machine tools with NC, they are being concentrated in specialized sections and equipped with a progressive cutting tool and multiplace, high-speed equipment. Sections and workshops of machine tools with CNC are being created in the leading enterprises. Operations for the creation of comprehensive automated sections and computer-controlled workshops are being conducted on the basis of standardized volume layouts and technological designs, a system of group control for machine tools (GUS), and control systems for automated transport-warehouse complexes (ATSK), automated storage complexes (AKN), the work stations of programmer-technologists (ARMTP) and others. A computer also monitors and controls operation of the system for periodic preventive maintenance of the work stations (PPORM), and monitors operation time of the equipment and the cutting tool, ensuring compulsory replacement of the cutting tool, a record of stock supply and expenditure, processed components and others.

The standardized layout of one of the variants of the ATK controlled from a computer is shown in figure 1.

The ATK consists of several automated technological modules (ATM)1 and of one combined receipt-dispatch module (OPOM) 2 which combines the functions of stock-component storage and position monitoring.

Each ATM unites two machine tools 3 with NC equipped with automatic manipulators 4 and two machine tool receipt-dispatch modules (SPOM).

The combined OPOM and the machine tool SPOM consist of integral unified units: an automated storage rack 5, an automatic manipulator 6 and receipt-dispatch tables 7.

As indicated in figure 1, it is possible to put together an ATK with a single-row arrangement (linear) from a collection of ATM's and with a multiple-row arrangement of ATM's one that makes it possible to create the optimum variants of GAK and GAP.

An automatic manipulator 8 is installed in the OPOM which sends the package with components to the monitor or dispatch positions located on the left and the right of the receipt-dispatch tables.